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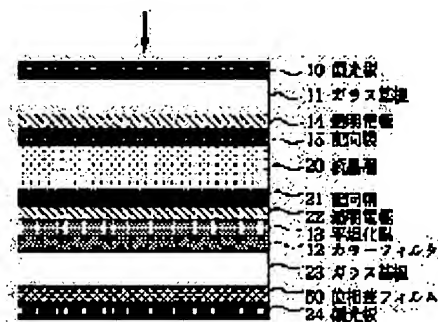
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(54) LIQUID CRYSTAL ELEMENT AND LIQUID CRYSTAL DEVICE

(57)Abstract:

PROBLEM TO BE SOLVED: To improve optical characteristics and visual field angle characteristics by providing a 1st uniaxial optically anisotropic member which has its optical axis oriented at right angles to the substrate surface of the liquid crystal element and a 2nd uniaxial optically anisotropic member which is different in the sign of optical anisotropy from the 1st member.

SOLUTION: This element is composed of polarizing plates 10 and 24, glass substrates 11 and 23 between which liquid crystal is sandwiched, a color filter 12 which has specific spectral characteristics, a flattening film 13 which corrects unevenness of the color filter 12, transparent electrodes 14 and 22 which apply a voltage to the liquid crystal, pixel by pixel, orientation films 15 and 21 which orient the liquid crystal in a desired orientation state, a liquid crystal layer 20, and a phase difference film (birefringent film and retardation film) 50 which has positive uniaxial anisotropy and is perpendicular to the glass substrates 11 and 23. Then the retardation of the 1st uniaxial optical anisotropic member which is oriented at right angles to the substrate surface of the liquid crystal element is compensated by the 2nd uniaxial anisotropic member which is different in the sign of anisotropy from the 1st uniaxial optical anisotropic member and oriented at right angles to the substrate surface of the liquid crystal element.



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CLAIMS

[Claim(s)]

[Claim 1] The liquid crystal device characterized by having the second optically uniaxial optical different direction member from which an optical axis carries out orientation to the first optically uniaxial optical different direction member in which the optical axis carried out orientation vertically to the substrate side of this liquid crystal device vertically to the substrate side of this liquid crystal device in the liquid crystal device which pinched liquid crystal between the substrates of the couple which counters, and the positive/negative of the optically uniaxial optical different direction member of this first and an optical anisotropy differs.

[Claim 2] In the liquid crystal device which has the first optically uniaxial optical different direction member in which pinched liquid crystal between the substrates of the couple which counters, and the optical axis carried out orientation vertically to the substrate side of this liquid crystal device between this substrate and this liquid crystal The liquid crystal device characterized by having the second optically uniaxial optical different direction member from which an optical axis carries out orientation vertically to the substrate side of this liquid crystal device to this liquid crystal and the opposite hand of a substrate of this couple, and the positive/negative of the optically uniaxial optical different direction member of this first and an optical anisotropy differs in them.

[Claim 3] A liquid crystal device given in either claim 1 to which the first [said] optically uniaxial optical different direction member is characterized by having a forward optical anisotropy and the second [said] optically uniaxial optical different direction member having the negative optical anisotropy, or claim 2.

[Claim 4] A liquid crystal device given in either claim 1 to which the first [said] optically uniaxial optical different direction member is characterized by having a negative optical anisotropy and the second [said] optically uniaxial optical different direction member having the forward optical anisotropy, or claim 2.

[Claim 5] The liquid crystal device according to claim 1 to 4 characterized by the first [said] optically uniaxial optical different direction member consisting of a polyamide thru/or polyimide.

[Claim 6] The liquid crystal device according to claim 1 to 5 characterized by the first [said] optically uniaxial optical different direction member being a light filter.

[Claim 7] The liquid crystal device according to claim 1 to 6 characterized by the second [said] optically uniaxial optical different direction member coming to have a birefringence high polymer film at least.

[Claim 8] The liquid crystal device according to claim 1 to 7 characterized by the second [said] optically uniaxial optical different direction member coming to have a side-chain mold liquid crystallinity macromolecule at least.

[Claim 9] The liquid crystal device according to claim 8 characterized by the second [said] optically uniaxial optical different direction member coming to apply a side-chain mold liquid crystallinity macromolecule to a high polymer film.

[Claim 10] The liquid crystal device according to claim 1 to 9 to which the value of the retardation of

the first [said] optically uniaxial optical different direction member and the value of the retardation of the second [said] optically uniaxial optical different direction member are characterized by the equal thing.

[Claim 11] The liquid crystal device according to claim 1 to 10 characterized by for the first [said] optically uniaxial optical different direction member and the second [said] optically uniaxial optical different direction member seeing from a liquid crystal layer, and being in the same side.

[Claim 12] The liquid crystal device according to claim 1 to 11 characterized by the maximum of the retardation of the second [said] optically uniaxial optical different direction member being 30-360nm.

[Claim 13] The liquid crystal device according to claim 1 to 12 characterized by said liquid crystal being a pneumatic liquid crystal.

[Claim 14] The liquid crystal device according to claim 1 to 12 characterized by said liquid crystal being chiral smectic liquid crystal.

[Claim 15] The liquid crystal device according to claim 14 characterized by said liquid crystal being a ferroelectric liquid crystal.

[Claim 16] Liquid crystal equipment which has a means to drive a liquid crystal device and this liquid crystal device according to claim 1 to 15.

[Claim 17] The liquid crystal display using liquid crystal equipment according to claim 16.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to an improvement of the angle-of-visibility property of a liquid crystal display especially about a liquid crystal device and liquid crystal equipment.

[0002]

[Description of the Prior Art] In order to clarify the background of this invention, with reference to drawing, fundamental actuation of a liquid crystal display is explained briefly.

[0003] Drawing 11 is the typical sectional view showing an example of a liquid crystal device.

[0004] This component consists of orientation film 105 and 111 for carrying out orientation of polarizing plates 100 and 114, the glass substrates 101 and 113 which pinch liquid crystal, the light filter 102 which has the predetermined spectral characteristic, the transparent electrodes 104 and 112 which impress an electrical potential difference to the 103 pixel flattening film which amends the irregularity of a light filter, and the liquid crystal, and a liquid crystal layer 110.

[0005] The liquid crystal layer 110 pinched with the glass substrates 101 and 113 of a vertical couple is in the orientation condition predetermined in the electrical-potential-difference condition of not impressing, with the orientation film 105 and 111 prepared in the substrate side which touches the liquid crystal layer 110. As orientation film, what carried out rubbing processing of the organic poly membranes, such as polyimide, is used.

[0006] here -- between vertical substrates -- 90 degrees -- it can twist and is in an orientation condition -- it can twist, pneumatic (it omits Twisted Nematic and Following TN) liquid crystal is made into an example, and the optical actuation is described. In TN liquid crystal device at the time of no electrical-potential-difference impressing, after passing a glass substrate 101, a transparent electrode 104, and the orientation film 105, incidence of the light which passed the polarizing plate 100 by the side of incidence is carried out in the direction of an optical axis of the liquid crystal molecule in the liquid crystal layer 110, and it can twist the liquid crystal layer 110 and carries out the rotatory polarization in accordance with an array. Consequently, plane of polarization is rotating 90 degrees of light which carried out outgoing radiation from the liquid crystal layer 110, in view of incident light. The light which carried out outgoing radiation from this liquid crystal layer 110 reaches the polarizing plate 114 by the side of outgoing radiation, after passing the orientation film 111, a transparent electrode 112, the flattening film 103, a light filter 102, and a glass substrate 113. Since the polarization shaft of the polarizing plate 114 by the side of outgoing radiation is set as the rectangular cross to the polarization shaft of the polarizing plate 100 by the side of incidence, light penetrates it, and a white display is made.

[0007] Since the array of the liquid crystal molecule in the liquid crystal layer 110 changes and a liquid crystal molecule arranges to electric field on the other hand at parallel when sufficient electrical potential difference is impressed, the rotatory-polarization operation mentioned above is lost. Therefore, in order that the plane of polarization of incident light may pass the liquid crystal layer 110 as it is, without rotating, it becomes plane of polarization vertical to the polarization shaft of the polarizing plate

114 by the side of outgoing radiation, and a polarizing plate 114 cannot be passed but a black display is made. Thus, a polarizing plate is arranged so that a mutual polarization shaft may intersect perpendicularly, and the display gestalt made to switch to a dark condition (black) from bright state (white) by electrical-potential-difference impression is called the Nor Marie White (positive) display.

[0008] Although the trouble that big-screen-izing is difficult is shown in the liquid crystal display using such a TN liquid crystal device and the active-matrix mold liquid crystal device which drives ***** of liquid crystal as a liquid crystal device which improves such a trouble using a super-***** pneumatic (it omits Super Twisted Nematic and Following STN) liquid crystal device, a thin film transistor (TFT), etc. which were enlarged is produced, fundamental optical actuation of liquid crystal is the same as that of TN liquid crystal device.

[0009] Moreover, there is a ferroelectric liquid crystal component using the refractive-index anisotropy of a ferroelectric liquid crystal molecule, and the surface passivation ferroelectric liquid crystal (SSFLC) component which has memory nature especially by Clark and Lagerwall is proposed (JP,56-107216,A, U.S. Pat. No. 4367924 number description, etc.). This SSFLC component makes a liquid crystal molecule switch between that 1st stable state and 2nd stable state, and performs monochrome display by combining two polarizing plates arranged to the cross Nicol's prism at it.

[0010] The typical perspective view of a SSFLC component is shown in drawing 12. In drawing 12, the 1st and 2nd stable state of a ferroelectric liquid crystal, and 134a and 134b look up, respectively, and an electrode for the vertical substrate with which 121a and 121b pinch liquid crystal, and 122 to impress 131a, and for a ferroelectric liquid crystal layer and 131b impress an electrical potential difference, and 133a and 133b are the downward dipole moments. Other than these, a polarizing plate, a transparent electrode, the orientation film, etc. are prepared (not shown).

[0011] A ferroelectric liquid crystal is chiral smectic liquid crystal which generally has a chiral smectic C (SmC*) phase or H (SmH*) phase in a specific temperature region. And in SSFLC, this ferroelectric liquid crystal is used as a non-spiral condition. In this condition, if electric fields E_a and E_b arise with the electrical potential difference impressed to Electrodes 131a and 131b, as for a liquid crystal molecule, the dipole moment of a liquid crystal molecule will take the 1st stable state 133a and 2nd stable state 133b for upward 134a and downward 134b according to the sense and it, respectively.

[0012] The light transmittance of SSFLC when two polarizing plates have been arranged to the cross Nicol's prism is $I/I_0 = \sin^2 2\alpha \sin^2 (\delta/2)$.

(-- I:transmitted light reinforcement and I_0 -- : -- incident light -- reinforcement -- α -- : -- liquid crystal -- a molecule -- an optical axis -- one side -- a polarizing plate -- polarization -- a shaft -- making -- an angle -- δ -- n -- : -- a refractive index -- an anisotropy -- d -- : -- liquid crystal -- a layer -- thickness -- λ -- : -- incident light -- wavelength --) -- expressing -- having. Usually, the optical axis of a liquid crystal molecule is in agreement with the major axis of a liquid crystal molecule.

[0013] According to the above-mentioned formula, when the angle which permeability is set to 0 when a liquid crystal molecule shaft is parallel to the polarization shaft of one polarizing plate, and a liquid crystal molecule shaft and the polarization shaft of a polarizing plate make is 45 degrees, permeability serves as max. That is, when making it a liquid crystal molecule shaft become the polarization shaft of one polarizing plate, and parallel in the case of the 1st above-mentioned stable state, it considers as a dark condition (black), and as a liquid crystal molecule shaft has a certain include angle to the polarization shaft of a polarizing plate, it considers as bright state (white) in the case of the 2nd stable state.

[0014] In the liquid crystal display using such a liquid crystal device, the angle-of-visibility property that the display engine performance changes with directions to see poses a problem conventionally.

[0015] The cause of angle-of-visibility property aggravation is described below. Light transmittance I/I_0 of TN liquid crystal which was used as the polarization shaft of two polarizing plates at parallel according to Gooch and Tarry (Applied Physics vol.8(1985) P.1575) $I/I_0 = \sin^2 [\pi(1+u^2)^{1/2}]/(1+u^2)$ It is come out and expressed. I is transmitted light reinforcement and I_0 here. They are incident light reinforcement and $u=2\delta n d/\lambda$ (thickness of absolute-value $|n_e-n_o|$ of the difference of the rate of the abnormality optical refraction in δn ., and the rate n_o of usual-state optical refraction, and

d:liquid-crystal layer, λ : wavelength). Here, $\Delta n d$ is called retardation. That is, the light transmittance of a liquid crystal cell changes with values of retardation $R_{lc} = \Delta n d$ of a liquid crystal layer. Therefore, a display property can be made the optimal if R_{lc} is designed the optimal. However, n_e It changes according to the incident angle of incident light. therefore -- even when R_{lc} is optimized to the light which carried out incidence at right angles to a substrate side, in order that [for example,] the incident light from slant may pass through the inside of a liquid crystal layer aslant -- n_e Change will arise in R_{lc} with change and the incident angle dependency of permeability will arise. Moreover, orientation of the liquid crystal molecule is carried out in the fixed direction with the so-called pre tilt angle to a substrate whenever [fixed angle]. Thus, since the orientation of a liquid crystal molecule is unsymmetrical, even if an incident angle is equal, the unsymmetrical angle-of-visibility property that R_{lc} changes with sense arises.

[0016] Now, as mentioned above, the light transmittance of SSFLC is $I/I_0 = \sin^2 2\alpha \sin^2 (\pi \Delta n d / \lambda)$.

It is come out and expressed.

[0017] Also in SSFLC, the point that the light transmittance of a liquid crystal cell changes with values of retardation $R_{lc} = \Delta n d$ of a liquid crystal layer is the same as that of TN liquid crystal. Moreover, the point which the incident angle dependency of permeability produces, and the point that an unsymmetrical angle-of-visibility property arises with the asymmetry of the orientation of a liquid crystal molecule are the same as that of TN liquid crystal.

[0018] There is a technique indicated by JP,5-232464,A of using two or more optical different direction components from which a retardation value differs, for example as an approach of amending the asymmetry of R_{lc} in TN liquid crystal device.

[0019] However, it became clear that aggravation of such an angle-of-visibility property had a cause not only in the problem of the liquid crystal itself but in the various members currently used for the liquid crystal device. Next, the explanation is performed.

[0020] In this description, the thing of the birefringence anisotropy expressed by the retardation etc. is called optical anisotropy.

[0021] As an ingredient of a light filter 102, the flattening film 103, and the orientation film 105 and 111, although polyimide system resin, polyamide system resin, acrylic resin, epoxy system resin, etc. are known, a birefringence may arise on a light filter, the flattening film, the orientation film, etc. by using these ingredients.

[0022] The result of having measured the refractive index of a polyamide as an example is shown in a table 1. Here, the X-axis and a Y-axis take the Z-axis at right angles to the screen (substrate side) for the screen (substrate side) and parallel about a refractive index n_i ($i=X, Y, Z$). A polyamide has negative uniaxial anisotropy and the optical axis is carrying out orientation in the direction (Z shaft orientations) vertical to the screen so that clearly from a table 1. here -- rate no of usual state optical refraction n_X and n_Y equal -- rate ne of abnormality optical refraction n_Z the above -- n_X -- it is the following (n_Y). It is $n_e = n_o$ when light carries out incidence from a direction (Z shaft orientations) vertical to the screen. It is n_e as whenever [incident angle] becomes large, although it becomes and is changeless in a display property. A value becomes small and $|n_e - n_o|$ becomes large in connection with it. That is, unnecessary retardation $R_{pa} = \Delta n d$ (it is absolute value $|n_e - n_o|$ of the difference of the rate ne of the abnormality optical refraction in Δn :and the rate no of usual state optical refraction, and, in the case of a polyamide, the maximum of Δn is the thickness of 0.045 and d:polyamide film from a table 1) by the polyamide arises. And additional R_{pa} will join R_{lc} optimized with the liquid crystal simple substance, and display engine performance, such as an angle-of-visibility property, will get worse.

[0023]

[A table 1]

表 1

n_x	1.680
n_y	1.680
n_z	1.635

[0024] However, it was to this problem, without finding out a fundamental solution.

[0025]

[Problem(s) to be Solved by the Invention] It is this invention's being made in view of the above-mentioned situation, and the place made into the technical problem of this invention compensating the retardation of the optically uniaxial optical different direction member which carried out orientation vertically to the substrate side, and providing the liquid crystal device of the outstanding optical property and liquid crystal equipment, and a list with the liquid crystal display component and liquid crystal display whose angle-of-visibility property's improved.

[0026] Especially, this invention compensates the retardation of a member which has the negative optically uniaxial optical anisotropy which carried out orientation vertically to the screen in a liquid crystal device, and aims at offering the liquid crystal display component and liquid crystal display which were excellent in the angle-of-visibility property.

[0027]

[Means for Solving the Problem] In the liquid crystal device which pinched liquid crystal between the substrates of the couple which is made in order that this invention may solve the above-mentioned technical problem, and counters The first optically uniaxial optical different direction member in which the optical axis carried out orientation vertically to the substrate side of this liquid crystal device, It is the liquid crystal device characterized by having the second optically uniaxial optical different direction member from which an optical axis carries out orientation vertically to the substrate side of this liquid crystal device, and the positive/negative of the optically uniaxial optical different direction member of this first and an optical anisotropy differs.

[0028] This invention pinches liquid crystal between the substrates of the couple which counters. Moreover, between this substrate and this liquid crystal In the liquid crystal device which has the first optically uniaxial optical different direction member in which the optical axis carried out orientation vertically to the substrate side of this liquid crystal device It is the liquid crystal device characterized by having the second optically uniaxial optical different direction member from which an optical axis carries out orientation vertically to the substrate side of this liquid crystal device to the outside of the substrate of this couple, and the positive/negative of the optically uniaxial optical different direction member of this first and an optical anisotropy differs on it.

[0029] It is the liquid crystal device in which the first mode of this invention has a 1 shaft optical anisotropy negative in the first [said] optically uniaxial optical different direction member, and the second [said] optically uniaxial optical different direction member has the forward 1 shaft optical anisotropy.

[0030] It is the liquid crystal device in which the second mode of this invention has a 1 shaft optical anisotropy forward in the first [said] optically uniaxial optical different direction member, and the second [said] optically uniaxial different direction member has the negative 1 shaft optical anisotropy.

[0031] As first [said] optically uniaxial optical different direction member, although organic macromolecules, such as polyimide and a polyamide, etc. are used, as long as it has the optically uniaxial optical anisotropy, you may be what kind of thing. Moreover, as for the first [said] optically uniaxial optical different direction member, it is desirable that they are functional members, such as a light filter and flattening film.

[0032] Although various things may be used as second [said] optically uniaxial optical different direction member, the birefringence film which consists of a macromolecule is used suitably, and what applied the side-chain mold polymer liquid crystal to the film which consists of a macromolecule etc. is

used suitably.

[0033] Moreover, as for the value of the retardation of the second [said] optically uniaxial optical different direction member, it is desirable that it is equal to the value of the retardation of the first [said] optically uniaxial optical different direction member.

[0034] Furthermore, as for the maximum of the retardation of the second [said] optically uniaxial optical different direction member, it is more desirable that it is 30-360nm.

[0035] As for the first [said] optically uniaxial optical different direction member and the second [said] optically uniaxial optical different direction member, it is desirable that it sees from a liquid crystal layer and is in the same side at the point that the polarization which passes a liquid crystal layer turns into the linearly polarized light.

[0036] Moreover, as for the second [said] optically uniaxial optical different direction member, it is desirable that it sees from a liquid crystal layer and is in an outgoing radiation side at the point that the design of equipment becomes simple.

[0037] As liquid crystal used for the liquid crystal device of this invention, chiral smectic liquid crystal, such as TN liquid crystal mentioned above, STN LCD, a ferroelectric liquid crystal, and/or antiferroelectricity liquid crystal, etc. is used suitably. Moreover, as a method of driving liquid crystal, a simple matrix method, an active-matrix method, etc. are used suitably.

[0038] According to this invention, a retardation is compensated by an optical's axis carrying out orientation of the liquid crystal device vertically to the substrate side of this liquid crystal device, and considering as the configuration which has arranged the first [from which the positive/negative of an optical anisotropy differs mutually], and second optical different direction members.

[0039]

[Embodiment of the Invention] The gestalt of operation of this invention is explained to a detail using a drawing below.

[0040] Drawing 1 is a typical sectional view showing the first example of the liquid crystal device concerning this invention. This example is related with an electrochromatic display device.

[0041] This component has polarizing plates 10 and 24, the glass substrates 11 and 23 which pinch liquid crystal, the light filter 12 which has the predetermined spectral characteristic, the flattening film 13 which amends the irregularity of a light filter, the transparent electrodes 14 and 22 which impress an electrical potential difference to liquid crystal per pixel, the orientation film 15 and 21 which changes the orientation of the liquid crystal into a desired orientation condition, the liquid crystal layer 20, and forward uniaxial anisotropy, and the optical axis consists of a vertical phase contrast film (a birefringence film, retardation film) 50 to the glass substrate.

[0042] A light filter 12 and the flattening film 13 consist of ingredients, such as polyamide system resin which has a negative optically uniaxial optical anisotropy, polyimide system resin, acrylic resin, and epoxy system resin, by processing of a spin coat, a roll coat, etc., are prepared on a substrate and are carrying out orientation vertically to the substrate side. In addition, a light filter 12 or the flattening film 13 may be carrying out orientation at right angles to a substrate side, and the flattening film 13 does not need to exist further. Moreover, a light filter 12 and the flattening film 13 may be arranged between the orientation film 21 and a transparent electrode 22. Moreover, you may be the member which members, such as an insulator layer, may be prepared besides the above-mentioned member, and these members have an optical anisotropy, and carried out orientation at right angles to a substrate side.

[0043] The phase contrast film 50 is produced by controlling the orientation and birefringence in a film and giving a desired optical anisotropy by performing compression and processing of a drawing to high polymer films, such as a polycarbonate, Pori Sall John, and polyarylate. Moreover, the phase contrast film 50 is also producible by making the optical anisotropy of a meso gene radical discover by controlling the higher order structure of a polymer liquid crystal.

[0044] Moreover, by carrying out orientation of the side chain containing the meso gene of a side-chain mold polymer liquid crystal vertically to a substrate side, an optical anisotropy can be made to be able to discover and the phase contrast film 50 can also be produced.

[0045] With the orientation film 15 and 21 which consists of polyimide prepared in the field which

touched the liquid crystal layer 20, orientation processing is made and the liquid crystal layer 20 pinched with the glass substrates 11 and 23 of a vertical couple serves as orientation predetermined in the electrical-potential-difference condition of not impressing. Various liquid crystal, such as a pneumatic liquid crystal and chiral smectic liquid crystal, is used for the liquid crystal layer 20.

[0046] Next, the polarization condition of this component is explained.

[0047] As for drawing 2, only the member to which a polarization condition is changed among these components extracts and shows (a polarizing plate 10, a light filter 12, the flattening film 13, the liquid crystal layer 20, the phase contrast film 50, and the polarizing plate 24). The light which carries out incidence of 52 to this component, and the light to which polarization of the outgoing radiation light from a light filter 12 and the flattening film 13 and 56 pass polarization of the outgoing radiation light from the phase contrast film 50, 57 passes a polarizing plate 24, and polarization of the outgoing radiation light from a polarizing plate 10 and 54 carry out outgoing radiation of 53 for polarization of the outgoing radiation light from the liquid crystal layer 20 and 55 from this component are shown. However, incident light 52 presupposes that incidence is carried out from across with a certain include angle to the screen. In addition, the liquid crystal layer 20 is TN liquid crystal layer, and drawing 2 is the case where it is indicating by white.

[0048] In drawing 2, the incident light 52 which has random polarization turns into the linearly polarized light 53 with a polarizing plate 10. 90 degrees of plane of polarization rotate in the liquid crystal layer 20, and the linearly polarized light 53 turns into the linearly polarized light 54. Since the light filter 12 and the flattening film 13 which have retardation δ and have a negative 1 shaft optical anisotropy with an optical axis vertical to the screen (substrate side), they give the phase contrast δ according to the incident angle to incident light. Therefore, the linearly polarized light 54 turns into elliptically polarized light 55 by passing a light filter 12 and the flattening film 13. On the other hand, since the phase contrast film 50 has a forward 1 shaft optical anisotropy with an optical axis vertical to the screen (substrate side), it gives phase contrast- δ of reverse to incident light in a light filter 12 and the flattening film 13. Therefore, elliptically polarized light 55 turns into the linearly polarized light 56 compensated for the phase by passing the phase contrast film 50. Since the linearly polarized light 56 is almost parallel to the polarization shaft of a polarizing plate 24 in the case of drawing 2, the reinforcement of the outgoing radiation light 57 is large, and a white display is obtained.

[0049] If the maximum of the rate of abnormality optical refraction sets to 3.0 micrometers thickness by which they set both light filter 12 and flattening film 13 since 1.635 and the rate of usual state optical refraction were 1.680 as shown in a table 1 when a polyamide is used for a light filter 12 and the flattening film 13, the maximum of δ will be set to 135nm and will use what has the forward 1 shaft optical anisotropy whose maximum of δ is 135nm as a phase contrast film 60. Usually, since the thickness of a phase contrast film is about 60 micrometers, the maximum of δ should just be about about 0.002.

[0050] Thus, since the phase contrast film 50 compensates the phase contrast δ produced by the light filter 12 and the flattening film 13, it can raise the angle-of-visibility property of a liquid crystal device.

[0051] In this example, the design of the phase contrast film 50 is easy. Even if various optical members to which polarization is changed exist, retardation value δ can be determined only in the state of the polarization 55 by the side of outgoing radiation, the condition of this polarization 55 is making it not form the phase contrast film 50 and a polarizing plate 24 in a liquid crystal device, and it is because it can measure easily. In addition, what is necessary is just to set up retardation value δ of the phase contrast film 50 so that the polarization shaft-orientations component of the polarizing plate 24 of polarization 56 may serve as max.

[0052] In addition, a light filter 12 and the flattening film 13 may be arranged at the incidence side of the liquid crystal layer 20.

[0053] Here, the case where the liquid crystal layer 20 is a SSFLC layer is briefly explained as a modification of this example.

[0054] In drawing 1, the incident light which has random polarization turns into the linearly polarized light parallel to the polarization shaft of a polarizing plate 10 by passing a polarizing plate 10. If it

explains taking the case of the case of a white display, the above-mentioned linearly polarized light will turn into polarization which has a component parallel to the polarization shaft of the polarizing plate 24 by the side of outgoing radiation by the birefringence anisotropy which the liquid crystal layer 20 has. Furthermore, the phase contrast delta according to the incident angle of incident light is given with a light filter 12 and the flattening film 13. And the phase contrast delta according to the incident angle of this incident light is compensated with the phase contrast film 50.

[0055] Next, the second example is explained. This example differs in the location of a phase contrast film from the first example. The typical sectional view showing the second example of a liquid crystal display component is shown in drawing 3.

[0056] In drawing 3, 60 is a phase contrast film and is inserted between the polarizing plates 10 and glass substrates 11 by the side of incidence. Since other members and those physical relationship are the same as that of drawing 1 (first example of an embodiment), the same sign as drawing 1 is attached and explanation is omitted.

[0057] Next, the polarization condition of this component is explained.

[0058] As for drawing 4, only the member to which a polarization condition is changed among these components extracts and shows (a polarizing plate 10, the phase contrast film 60, a light filter 12, the flattening film 13, the liquid crystal layer 20, and the polarizing plate 24). The light which carries out incidence of 62 to this component, and the light to which polarization of the outgoing radiation light from the liquid crystal layer 20 and 66 pass polarization of the outgoing radiation light from a light filter 12 and the flattening film 13, 67 passes a polarizing plate 24, and polarization of the outgoing radiation light from a polarizing plate 10 and 64 carry out outgoing radiation of 63 for polarization of the outgoing radiation light from the phase contrast film 60 and 65 from this component are shown. However, incident light 62 presupposes that incidence is carried out from across with a certain include angle to the screen. In addition, the liquid crystal layer 20 is TN liquid crystal layer, and drawing 4 is the case where it is indicating by white.

[0059] In drawing 4, the incident light 62 which has random polarization turns into the linearly polarized light 63 with a polarizing plate 10. Since the phase contrast film 60 which has retardation δ and has a forward 1 shaft optical anisotropy with an optical axis vertical to the screen (substrate side), it gives phase contrast-delta according to the incident angle to incident light. Therefore, the linearly polarized light 63 turns into elliptically polarized light 64 by passing the phase contrast film 60. 90 degrees of plane of polarization rotate in the liquid crystal layer 20, and elliptically polarized light 64 turns into elliptically polarized light 65. And since a light filter 12 and the flattening film 13 have a negative 1 shaft optical anisotropy with an optical axis vertical to the screen (substrate side), they give the phase contrast delta of reverse to incident light in the phase contrast film 60. Therefore, elliptically polarized light 65 turns into the linearly polarized light 66 by passing a light filter 12 and the flattening film 13. Since the linearly polarized light 66 is almost parallel to the polarization shaft of a polarizing plate 24 in the case of drawing 4, the reinforcement of the outgoing radiation light 67 is large, and a white display is obtained.

[0060] Thus, since the phase contrast film 60 compensates the phase contrast delta produced by the light filter 12 and the flattening film 13 by giving phase contrast-delta beforehand to polarization, it can raise the angle-of-visibility property of a liquid crystal device.

[0061] In addition, a light filter 12 and the flattening film 13 are seen from the liquid crystal layer 20, and may be arranged at the incidence side of light.

[0062] As the third example, the same liquid crystal display component as the second example is explained except arranging a light filter 12 and the flattening film 13 to the incidence side of the liquid crystal layer 20.

[0063] The typical sectional view showing the third example of a liquid crystal display component is shown in drawing 5. Moreover, only the member to which a polarization condition is changed among these components is extracted, and it is shown in drawing 6. In addition, the liquid crystal layer 20 is TN liquid crystal layer, and drawing 6 is the case where it is indicating by white.

[0064] In drawing 6, the incident light 32 which has random polarization turns into the linearly

polarized light 33 with a polarizing plate 10. Since the phase contrast film 30 which has retardation δ and has a forward 1 shaft optical anisotropy with an optical axis vertical to the screen (substrate side), it gives phase contrast- δ according to the inclination to incident light. Therefore, the linearly polarized light 33 turns into elliptically polarized light 34 by passing the phase contrast film 30. Since a light filter 12 and the flattening film 13 have a negative 1 shaft optical anisotropy with an optical axis vertical to the screen (substrate side), they give the phase contrast δ of reverse to incident light in the phase contrast film 30. Therefore, elliptically polarized light 34 turns into the linearly polarized light 35 by passing a light filter 12 and the flattening film 13. And 90 degrees of plane of polarization rotate in the liquid crystal layer 20, and the linearly polarized light 35 turns into the linearly polarized light 36. Since the linearly polarized light 36 is almost parallel to the polarization shaft of a polarizing plate 24 in the case of drawing 6, the reinforcement of the outgoing radiation light 37 is large, and a white display is obtained.

[0065] Thus, since the phase contrast film 30 compensates the phase contrast δ produced by the light filter 12 and the flattening film 13 by giving phase contrast- δ beforehand to polarization, it can raise the angle-of-visibility property of a liquid crystal device.

[0066] Moreover, a phase contrast film may be inserted between a glass substrate 23 and the polarizing plate 24 by the side of outgoing radiation, as shown in drawing 7.

[0067] As for a phase contrast film, a light filter 12, and the flattening film 13, in the above example, it is more desirable that it sees from the liquid crystal layer 20, and is in the same side. By seeing these from the liquid crystal layer 20, and arranging to the same side, it is because the polarization which passes the liquid crystal layer 20 turns into the linearly polarized light. If the polarization which passes a liquid crystal layer turns into elliptically polarized light, in the case of TN liquid crystal device, 90 degrees of plane of polarization may not rotate thoroughly, but the display engine performance may be inferior.

[0068] Moreover, generally the thickness of a light filter 12 and the flattening film 13 is 1-2 micrometers and about 2-4 micrometers, respectively, and since the maximum of δ is 0.03 to about 0.06, the maximum of retardation δ of a phase contrast film is suitably chosen in 30-360nm.

[0069] In the above example, although explained mainly taking the case of TN liquid crystal device, even if STN, SSFLC(s), etc. are the other modes, the operation of this invention to the optical anisotropy produced by members other than liquid crystal is the same.

[0070] The example of an experiment of this invention is continuously explained using a drawing. The following examples of an experiment are related with the surface passivation ferroelectric liquid crystal (SSFLC) component which used chiral smectic liquid crystal.

[0071] (Example 1 of an experiment) After forming Cr film in the glass substrate of 300mmx320mm and 1.1mm thickness by the sputter, by the photolithography, patterning was carried out and the protection-from-light layer of 100nm of thickness was formed in it. Next, after applying with a spinner the polyimide system photopolymer with which the pigment was distributed, patterning was carried out by the photolithography and the light filter film of 1.5 micrometers of thickness was formed (R, G, and B). Furthermore, the polyamide system flattening film of 1.5 micrometers of thickness was formed by coating. Then, after forming ITO by the sputter, by the photolithography, patterning was carried out and the transparent electrode of the shape of a stripe of 150nm of thickness was formed. Then, the polyimide system orientation film of 20nm of thickness was formed by flexographic printing and baking, and rubbing processing was performed.

[0072] By making the substrate which prepared an ITO transparent electrode and the polyimide system orientation film, and carried out rubbing processing counter, and sticking with epoxy system adhesives on a substrate, similarly, the liquid crystal cell was produced, and level orientation of the chiral smectic liquid crystal constituent of a pyrimidine system was poured in and carried out.

[0073] It continued and the birefringence film which has the forward optical anisotropy which carried out vertical orientation was obtained by applying a side-chain mold liquid crystallinity macromolecule to a high polymer film. And this birefringence film was stuck on the outside of the substrate which has a light filter, and the polarizing plate was stuck on the outside of a both-sides substrate at the cross Nicol's

prism. And the back light was prepared so that light might carry out incidence from the substrate side which does not have a light filter, the electrical-potential-difference impression means was established by the well-known approach, and it considered as the liquid crystal display.

[0074] Thus, it is as the typical sectional view being shown in drawing 1 in the first example of an embodiment which mentioned the produced liquid crystal display above.

[0075] The maximum of d_{tand} which the sum d of the thickness of a light filter and the flattening film produced by 3.0 micrometers and these was 135nm. In this example of an experiment, it designed so that the maximum of d_{tand} of a birefringence film might be set to 135nm.

[0076] The result of having measured the angle-of-visibility property in the liquid crystal display of this example of an experiment is shown in drawing 8. ϕ in drawing 8 and θ express the azimuth of the transmitted light projected on the screen, respectively, and the angle of inclination from a screen normal as they are shown in drawing 10. Moreover, the curve in drawing 8 is a ** contrast curve, and it is shown that the inside serves as high contrast. The azimuth dependency of contrast is small and the liquid crystal display of this example is dramatically excellent in the angle-of-visibility property.

[0077] (Example 2 of an experiment) The liquid crystal display was produced like the example 1 of an experiment. However, the birefringence film was not prepared.

[0078] The result of having measured the angle-of-visibility property in the liquid crystal display of this example of an experiment is shown in drawing 9. An azimuth shows that is large and an angle-of-visibility property is not so good. [of change of contrast]

[0079] (Example 3 of an experiment) The liquid crystal display was produced like the example 1 of an experiment. However, the birefringence film was prepared in the outside (between a glass substrate and polarizing plates) of the substrate which does not have a light filter. It is as the typical sectional view being shown in drawing 3 in the second example of an embodiment which mentioned above the liquid crystal display of this example of an experiment.

[0080] When the angle-of-visibility property in the liquid crystal display of this example of an experiment was measured, it turned out like the example 1 of an experiment that the azimuth dependency of contrast is small and the angle-of-visibility property is dramatically excellent.

[0081] (Example 4 of an experiment) The liquid crystal display was produced like the example 1 of an experiment. However, the birefringence film was prepared in the outside of a both-sides substrate.

[0082] When the angle-of-visibility property in the liquid crystal display of this example of an experiment was measured, it turned out like the example 1 of an experiment that the azimuth dependency of contrast is small and the angle-of-visibility property is dramatically excellent.

[0083] The examples 1, 3, and 4 of an experiment are examples of this invention among the above example of an experiment, and the example 2 of an experiment is an example of a comparison. By preparing a phase contrast film shows that the angle-of-visibility property is improved substantially so that clearly from the comparison of the example 1 (drawing 8) of an experiment, and the example 2 (drawing 9) of an experiment.

[0084] Although the above-mentioned example of an experiment was performed using chiral smectic liquid crystal, other liquid crystal may be used. Moreover, it may not be what also restricted the liquid crystal device of this invention thru/or the configuration of a liquid crystal display to the above-mentioned example of an embodiment, and the example of an experiment, for example, you may be a liquid crystal display component, a liquid crystal shutter, etc. in monochrome mode in which a light filter is not prepared.

[0085]

[Effect of the Invention] As explained in full detail above, according to this invention, the retardation of the first optically uniaxial optical different direction member which carried out orientation vertically to the substrate side of a liquid crystal device By compensating by the second optically uniaxial optical different direction member in which the positive/negative of an anisotropy carried out orientation vertically to the substrate side of a liquid crystal device unlike the first [said] optically uniaxial optical different direction member The liquid crystal device of the outstanding optical property and liquid crystal equipment, and a list can be provided with the liquid crystal display component and liquid crystal

display whose angle-of-visibility property improved.

[0086] Especially, according to this invention, the liquid crystal device of the outstanding optical property and liquid crystal equipment, and a list can be provided with the liquid crystal display component and liquid crystal display whose angle-of-visibility property improved by compensating with the phase contrast film which has the forward optically uniaxial optical anisotropy which consists of a polymer liquid crystal etc. the negative retardation which optically uniaxial optical different direction members other than a liquid crystal layer, such as a light filter and flattening film, have.

[Translation done.]

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TECHNICAL FIELD

[Field of the Invention] This invention relates to an improvement of the angle-of-visibility property of a liquid crystal display especially about a liquid crystal device and liquid crystal equipment.

[Translation done.]

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PRIOR ART

[Description of the Prior Art] In order to clarify the background of this invention, with reference to drawing, fundamental actuation of a liquid crystal display is explained briefly.

[0003] Drawing 11 is the typical sectional view showing an example of a liquid crystal device.

[0004] This component consists of orientation film 105 and 111 for carrying out orientation of polarizing plates 100 and 114, the glass substrates 101 and 113 which pinch liquid crystal, the light filter 102 which has the predetermined spectral characteristic, the transparent electrodes 104 and 112 which impress an electrical potential difference to the 103 pixel flattening film which amends the irregularity of a light filter, and the liquid crystal, and a liquid crystal layer 110.

[0005] The liquid crystal layer 110 pinched with the glass substrates 101 and 113 of a vertical couple is in the orientation condition predetermined in the electrical-potential-difference condition of not impressing, with the orientation film 105 and 111 prepared in the substrate side which touches the liquid crystal layer 110. As orientation film, what carried out rubbing processing of the organic poly membranes, such as polyimide, is used.

[0006] here -- between vertical substrates -- 90 degrees -- it can twist and is in an orientation condition -- it can twist, pneumatic (it omits Twisted Nematic and Following TN) liquid crystal is made into an example, and the optical actuation is described. In TN liquid crystal device at the time of no electrical-potential-difference impressing, after passing a glass substrate 101, a transparent electrode 104, and the orientation film 105, incidence of the light which passed the polarizing plate 100 by the side of incidence is carried out in the direction of an optical axis of the liquid crystal molecule in the liquid crystal layer 110, and it can twist the liquid crystal layer 110 and carries out the rotatory polarization in accordance with an array. Consequently, plane of polarization is rotating 90 degrees of light which carried out outgoing radiation from the liquid crystal layer 110, in view of incident light. The light which carried out outgoing radiation from this liquid crystal layer 110 reaches the polarizing plate 114 by the side of outgoing radiation, after passing the orientation film 111, a transparent electrode 112, the flattening film 103, a light filter 102, and a glass substrate 113. Since the polarization shaft of the polarizing plate 114 by the side of outgoing radiation is set as the rectangular cross to the polarization shaft of the polarizing plate 100 by the side of incidence, light penetrates it, and a white display is made.

[0007] Since the array of the liquid crystal molecule in the liquid crystal layer 110 changes and a liquid crystal molecule arranges to electric field on the other hand at parallel when sufficient electrical potential difference is impressed, the rotatory-polarization operation mentioned above is lost. Therefore, in order that the plane of polarization of incident light may pass the liquid crystal layer 110 as it is, without rotating, it becomes plane of polarization vertical to the polarization shaft of the polarizing plate 114 by the side of outgoing radiation, and a polarizing plate 114 cannot be passed but a black display is made. Thus, a polarizing plate is arranged so that a mutual polarization shaft may intersect perpendicularly, and the display gestalt made to switch to a dark condition (black) from bright state (white) by electrical-potential-difference impression is called the Nor Marie White (positive) display.

[0008] Although the trouble that big-screen-izing is difficult is shown in the liquid crystal display using

such a TN liquid crystal device and the active-matrix mold liquid crystal device which drives ***** of liquid crystal as a liquid crystal device which improves such a trouble using a super-***** pneumatic (it omits Super Twisted Nematic and Following STN) liquid crystal device, a thin film transistor (TFT), etc. which were enlarged is produced, fundamental optical actuation of liquid crystal is the same as that of TN liquid crystal device.

[0009] Moreover, there is a ferroelectric liquid crystal component using the refractive-index anisotropy of a ferroelectric liquid crystal molecule, and the surface passivation ferroelectric liquid crystal (SSFLC) component which has memory nature especially by Clark and Lagerwall is proposed (JP,56-107216,A, U.S. Pat. No. 4367924 number description, etc.). This SSFLC component makes a liquid crystal molecule switch between that 1st stable state and 2nd stable state, and performs monochrome display by combining two polarizing plates arranged to Kloss Nicol at it.

[0010] The typical perspective view of a SSFLC component is shown in drawing 12. In drawing 12, the 1st and 2nd stable state of a ferroelectric liquid crystal, and 134a and 134b look up, respectively, and an electrode for the vertical substrate with which 121a and 121b pinch liquid crystal, and 122 to impress 131a, and for a ferroelectric liquid crystal layer and 131b impress an electrical potential difference, and 133a and 133b are the downward dipole moments. Other than these, a polarizing plate, a transparent electrode, the orientation film, etc. are prepared (not shown).

[0011] A ferroelectric liquid crystal is chiral smectic liquid crystal which generally has a chiral smectic C (SmC*) phase or H (SmH*) phase in a specific temperature region. And in SSFLC, this ferroelectric liquid crystal is used as a non-spiral condition. In this condition, if electric fields E_a and E_b arise with the electrical potential difference impressed to Electrodes 131a and 131b, as for a liquid crystal molecule, the dipole moment of a liquid crystal molecule will take the 1st stable state 133a and 2nd stable state 133b for upward 134a and downward 134b according to the sense and it, respectively.

[0012] The light transmittance of SSFLC when two polarizing plates have been arranged to Kloss Nicol is $I/I_0 = \sin^2 2\alpha \sin^2 (\pi d \tan \delta / \lambda)$.

(-- I :transmitted light reinforcement and I_0 -- : -- incident light -- reinforcement -- α -- : -- liquid crystal -- a molecule -- an optical axis -- one side -- a polarizing plate -- polarization -- a shaft -- making -- an angle -- δ -- n -- : -- a refractive index -- an anisotropy -- d -- : -- liquid crystal -- a layer -- thickness -- λ -- : -- incident light -- wavelength --) -- expressing -- having. Usually, the optical axis of a liquid crystal molecule is in agreement with the major axis of a liquid crystal molecule.

[0013] According to the above-mentioned formula, when the angle which permeability is set to 0 when a liquid crystal molecule shaft is parallel to the polarization shaft of one polarizing plate, and a liquid crystal molecule shaft and the polarization shaft of a polarizing plate make is 45 degrees, permeability serves as max. That is, when making it a liquid crystal molecule shaft become the polarization shaft of one polarizing plate, and parallel in the case of the 1st above-mentioned stable state, it considers as a dark condition (black), and as a liquid crystal molecule shaft has a certain include angle to the polarization shaft of a polarizing plate, it considers as bright state (white) in the case of the 2nd stable state.

[0014] In the liquid crystal display using such a liquid crystal device, the angle-of-visibility property that the display engine performance changes with directions to see poses a problem conventionally.

[0015] The cause of angle-of-visibility property aggravation is described below. Light transmittance I/I_0 of TN liquid crystal which was used as the polarization shaft of two polarizing plates at parallel according to Gooch and Tarry (Applied Physics vol.8(1985) P.1575) $I/I_0 = \sin^2 [\pi(1+u^2)^{1/2}/(1+u^2)]$ It is come out and expressed. I is transmitted light reinforcement and I_0 here. They are incident light reinforcement and $u=2\delta n d/\lambda$ (thickness of absolute-value $|n_e-n_o|$ of the difference of the rate n_e of the abnormality optical refraction in δn ., and the rate n_o of usual-state optical refraction, and d :liquid-crystal layer, λ : wavelength). Here, $\delta n d$ is called retardation. That is, the light transmittance of a liquid crystal cell changes with values of retardation $R_{lc}=\delta n d$ of a liquid crystal layer. Therefore, a display property can be made the optimal if R_{lc} is designed the optimal. However, n_e It changes according to the incident angle of incident light. therefore -- even when R_{lc} is optimized to the light which carried out incidence at right angles to a substrate side, in order that [for example,] the

incident light from slant may pass through the inside of a liquid crystal layer aslant -- ne Change will arise in Rlc with change and the incident angle dependency of permeability will arise. Moreover, orientation of the liquid crystal molecule is carried out in the fixed direction with the so-called pre tilt angle to a substrate whenever [fixed angle]. Thus, since the orientation of a liquid crystal molecule is unsymmetrical, even if an incident angle is equal, the unsymmetrical angle-of-visibility property that Rlc changes with sense arises.

[0016] Now, as mentioned above, the light transmittance of SSFLC is $I/I_0 = \sin^2 2\alpha \sin^2 (\pi \delta / \lambda)$.

It is come out and expressed.

[0017] Also in SSFLC, the point that the light transmittance of a liquid crystal cell changes with values of retardation $R_{lc} = \delta n_d$ of a liquid crystal layer is the same as that of TN liquid crystal. Moreover, the point which the incident angle dependency of permeability produces, and the point that an unsymmetrical angle-of-visibility property arises with the asymmetry of the orientation of a liquid crystal molecule are the same as that of TN liquid crystal.

[0018] There is a technique indicated by JP,5-232464,A of using two or more optical different direction components from which a retardation value differs, for example as an approach of amending the asymmetry of Rlc in TN liquid crystal device.

[0019] However, it became clear that aggravation of such an angle-of-visibility property had a cause not only in the problem of the liquid crystal itself but in the various members currently used for the liquid crystal device. Next, the explanation is performed.

[0020] In this description, the thing of the birefringence anisotropy expressed by the retardation etc. is called optical anisotropy.

[0021] As an ingredient of a light filter 102, the flattening film 103, and the orientation film 105 and 111, although polyimide system resin, polyamide system resin, acrylic resin, epoxy system resin, etc. are known, a birefringence may arise on a light filter, the flattening film, the orientation film, etc. by using these ingredients.

[0022] The result of having measured the refractive index of a polyamide as an example is shown in a table 1. Here, the X-axis and a Y-axis take the Z-axis at right angles to the screen (substrate side) for the screen (substrate side) and parallel about a refractive index n_i ($i=X, Y, Z$). A polyamide has negative uniaxial anisotropy and the optical axis is carrying out orientation in the direction (Z shaft orientations) vertical to the screen so that clearly from a table 1. here -- rate no of usual state optical refraction n_X and n_Y equal -- rate ne of abnormality optical refraction n_Z the above -- n_X -- it is the following (n_Y). It is $n_e = n_o$ when light carries out incidence from a direction (Z shaft orientations) vertical to the screen. It is n_e as whenever [incident angle] becomes large, although it becomes and is changeless in a display property. A value becomes small and $|n_e - n_o|$ becomes large in connection with it. That is, unnecessary retardation $R_{pa} = \delta n_d$ (it is absolute value $|n_e - n_o|$ of the difference of the rate ne of the abnormality optical refraction in δn_d and the rate no of usual state optical refraction, and, in the case of a polyamide, the maximum of δn_d is the thickness of 0.045 and d:polyamide film from a table 1) by the polyamide arises. And additional R_{pa} will join Rlc optimized with the liquid crystal simple substance, and display engine performance, such as an angle-of-visibility property, will get worse.

[0023]

[A table 1]

表 1	
n_x	1.680
n_y	1.680
n_z	1.635

[0024] However, it was to this problem, without finding out a fundamental solution.

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EFFECT OF THE INVENTION

[Effect of the Invention] As explained in full detail above, according to this invention, the retardation of the first optically uniaxial optical different direction member which carried out orientation vertically to the substrate side of a liquid crystal device By compensating by the second optically uniaxial optical different direction member in which the positive/negative of an anisotropy carried out orientation vertically to the substrate side of a liquid crystal device unlike the first [said] optically uniaxial optical different direction member The liquid crystal device of the outstanding optical property and liquid crystal equipment, and a list can be provided with the liquid crystal display component and liquid crystal display whose angle-of-visibility property improved.

[0086] Especially, according to this invention, the liquid crystal device of the outstanding optical property and liquid crystal equipment, and a list can be provided with the liquid crystal display component and liquid crystal display whose angle-of-visibility property improved by compensating with the phase contrast film which has the forward optically uniaxial optical anisotropy which consists of a polymer liquid crystal etc. the negative retardation which optically uniaxial optical different direction members other than a liquid crystal layer, such as a light filter and flattening film, have.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] It is this invention's being made in view of the above-mentioned situation, and the place made into the technical problem of this invention compensating the retardation of the optically uniaxial optical different direction member which carried out orientation vertically to the substrate side, and providing the liquid crystal device of the outstanding optical property and liquid crystal equipment, and a list with the liquid crystal display component and liquid crystal display whose angle-of-visibility property's improved.

[0026] Especially, this invention compensates the retardation of a member which has the negative optically uniaxial optical anisotropy which carried out orientation vertically to the screen in a liquid crystal device, and aims at offering the liquid crystal display component and liquid crystal display which were excellent in the angle-of-visibility property.

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MEANS

[Means for Solving the Problem] In the liquid crystal device which pinched liquid crystal between the substrates of the couple which is made in order that this invention may solve the above-mentioned technical problem, and counters The first optically uniaxial optical different direction member in which the optical axis carried out orientation vertically to the substrate side of this liquid crystal device, It is the liquid crystal device characterized by having the second optically uniaxial optical different direction member from which an optical axis carries out orientation vertically to the substrate side of this liquid crystal device, and the positive/negative of the optically uniaxial optical different direction member of this first and an optical anisotropy differs.

[0028] This invention pinches liquid crystal between the substrates of the couple which counters. Moreover, between this substrate and this liquid crystal In the liquid crystal device which has the first optically uniaxial optical different direction member in which the optical axis carried out orientation vertically to the substrate side of this liquid crystal device It is the liquid crystal device characterized by having the second optically uniaxial optical different direction member from which an optical axis carries out orientation vertically to the substrate side of this liquid crystal device to the outside of the substrate of this couple, and the positive/negative of the optically uniaxial optical different direction member of this first and an optical anisotropy differs on it.

[0029] It is the liquid crystal device in which the first mode of this invention has a 1 shaft optical anisotropy negative in the first [said] optically uniaxial optical different direction member, and the second [said] optically uniaxial optical different direction member has the forward 1 shaft optical anisotropy.

[0030] It is the liquid crystal device in which the second mode of this invention has a 1 shaft optical anisotropy forward in the first [said] optically uniaxial optical different direction member, and the second [said] optically uniaxial different direction member has the negative 1 shaft optical anisotropy.

[0031] As first [said] optically uniaxial optical different direction member, although organic macromolecules, such as polyimide and a polyamide, etc. are used, as long as it has the optically uniaxial optical anisotropy, you may be what kind of thing. Moreover, as for the first [said] optically uniaxial optical different direction member, it is desirable that they are functional members, such as a light filter and flattening film.

[0032] Although various things may be used as second [said] optically uniaxial optical different direction member, the birefringence film which consists of a macromolecule is used suitably, and what applied the side-chain mold polymer liquid crystal to the film which consists of a macromolecule etc. is used suitably.

[0033] Moreover, as for the value of the retardation of the second [said] optically uniaxial optical different direction member, it is desirable that it is equal to the value of the retardation of the first [said] optically uniaxial optical different direction member.

[0034] Furthermore, as for the maximum of the retardation of the second [said] optically uniaxial optical different direction member, it is more desirable that it is 30-360nm.

[0035] As for the first [said] optically uniaxial optical different direction member and the second

[said] optically uniaxial optical different direction member, it is desirable that it sees from a liquid crystal layer and is in the same side at the point that the polarization which passes a liquid crystal layer turns into the linearly polarized light.

[0036] Moreover, as for the second [said] optically uniaxial optical different direction member, it is desirable that it sees from a liquid crystal layer and is in an outgoing radiation side at the point that the design of equipment becomes simple.

[0037] As liquid crystal used for the liquid crystal device of this invention, chiral smectic liquid crystal, such as TN liquid crystal mentioned above, STN LCD, a ferroelectric liquid crystal, and/or antiferroelectricity liquid crystal, etc. is used suitably. Moreover, as a method of driving liquid crystal, a simple matrix method, an active-matrix method, etc. are used suitably.

[0038] According to this invention, a retardation is compensated by an optical's axis carrying out orientation of the liquid crystal device vertically to the substrate side of this liquid crystal device, and considering as the configuration which has arranged the first [from which the positive/negative of an optical anisotropy differs mutually], and second optical different direction members:

[0039]

[Embodiment of the Invention] The gestalt of operation of this invention is explained to a detail using a drawing below.

[0040] Drawing 1 is a typical sectional view showing the first example of the liquid crystal device concerning this invention. This example is related with an electrochromatic display device.

[0041] This component has polarizing plates 10 and 24, the glass substrates 11 and 23 which pinch liquid crystal, the light filter 12 which has the predetermined spectral characteristic, the flattening film 13 which amends the irregularity of a light filter, the transparent electrodes 14 and 22 which impress an electrical potential difference to liquid crystal per pixel, the orientation film 15 and 21 which changes the orientation of the liquid crystal into a desired orientation condition, the liquid crystal layer 20, and forward uniaxial anisotropy, and the optical axis consists of a vertical phase contrast film (a birefringence film, retardation film) 50 to the glass substrate.

[0042] A light filter 12 and the flattening film 13 consist of ingredients, such as polyamide system resin which has a negative optically uniaxial optical anisotropy, polyimide system resin, acrylic resin, and epoxy system resin, by processing of a spin coat, a roll coat, etc., are prepared on a substrate and are carrying out orientation vertically to the substrate side. In addition, a light filter 12 or the flattening film 13 may be carrying out orientation at right angles to a substrate side, and the flattening film 13 does not need to exist further. Moreover, a light filter 12 and the flattening film 13 may be arranged between the orientation film 21 and a transparent electrode 22. Moreover, you may be the member which members, such as an insulator layer, may be prepared besides the above-mentioned member, and these members have an optical anisotropy, and carried out orientation at right angles to a substrate side.

[0043] The phase contrast film 50 is produced by controlling the orientation and birefringence in a film and giving a desired optical anisotropy by performing compression and processing of a drawing to high polymer films, such as a polycarbonate, Pori Sall John, and polyarylate. Moreover, the phase contrast film 50 is also producible by making the optical anisotropy of a meso gene radical discover by controlling the higher order structure of a polymer liquid crystal.

[0044] Moreover, by carrying out orientation of the side chain containing the meso gene of a side-chain mold polymer liquid crystal vertically to a substrate side, an optical anisotropy can be made to be able to discover and the phase contrast film 50 can also be produced.
 [0045] With the orientation film 15 and 21 which consists of polyimide prepared in the field which touched the liquid crystal layer 20, orientation processing is made and the liquid crystal layer 20 pinched with the glass substrates 11 and 23 of a vertical couple serves as orientation predetermined in the electrical-potential-difference condition of not impressing. Various liquid crystal, such as a pneumatic liquid crystal and chiral smectic liquid crystal, is used for the liquid crystal layer 20.

[0046] Next, the polarization condition of this component is explained.

[0047] As for drawing 2, only the member to which a polarization condition is changed among these components extracts and shows (a polarizing plate 10, a light filter 12, the flattening film 13, the liquid

crystal layer 20, the phase contrast film 50, and the polarizing plate 24). The light which carries out incidence of 52 to this component, and the light to which polarization of the outgoing radiation light from a light filter 12 and the flattening film 13 and 56 pass polarization of the outgoing radiation light from the phase contrast film 50, 57 passes a polarizing plate 24, and polarization of the outgoing radiation light from a polarizing plate 10 and 54 carry out outgoing radiation of 53 for polarization of the outgoing radiation light from the liquid crystal layer 20 and 55 from this component are shown. However, incident light 52 presupposes that incidence is carried out from across with a certain include angle to the screen. In addition, the liquid crystal layer 20 is TN liquid crystal layer, and drawing 2 is the case where it is indicating by white.

[0048] In drawing 2, the incident light 52 which has random polarization turns into the linearly polarized light 53 with a polarizing plate 10. 90 degrees of plane of polarization rotate in the liquid crystal layer 20, and the linearly polarized light 53 turns into the linearly polarized light 54. Since the light filter 12 and the flattening film 13 which have retardation δ have a negative 1 shaft optical anisotropy with an optical axis vertical to the screen (substrate side), they give the phase contrast δ according to the incident angle to incident light. Therefore, the linearly polarized light 54 turns into elliptically polarized light 55 by passing a light filter 12 and the flattening film 13. On the other hand, since the phase contrast film 50 has a forward 1 shaft optical anisotropy with an optical axis vertical to the screen (substrate side), it gives phase contrast- δ of reverse to incident light in a light filter 12 and the flattening film 13. Therefore, elliptically polarized light 55 turns into the linearly polarized light 56 compensated for the phase by passing the phase contrast film 50. Since the linearly polarized light 56 is almost parallel to the polarization shaft of a polarizing plate 24 in the case of drawing 2, the reinforcement of the outgoing radiation light 57 is large, and a white display is obtained.

[0049] If the maximum of the rate of abnormality optical refraction sets to 3.0 micrometers thickness by which they set both light filter 12 and flattening film 13 since 1.635 and the rate of usual state optical refraction were 1.680 as shown in a table 1 when a polyamide is used for a light filter 12 and the flattening film 13, the maximum of δ will be set to 135nm and will use what has the forward 1 shaft optical anisotropy whose maximum of δ is 135nm as a phase contrast film 60. Usually, since the thickness of a phase contrast film is about 60 micrometers, the maximum of δ should just be about about 0.002.

[0050] Thus, since the phase contrast film 50 compensates the phase contrast δ produced by the light filter 12 and the flattening film 13, it can raise the angle-of-visibility property of a liquid crystal device.

[0051] In this example, the design of the phase contrast film 50 is easy. Even if various optical members to which polarization is changed exist, retardation value δ can be determined only in the state of the polarization 55 by the side of outgoing radiation, the condition of this polarization 55 is making it not form the phase contrast film 50 and a polarizing plate 24 in a liquid crystal device, and it is because it can measure easily. In addition, what is necessary is just to set up retardation value δ of the phase contrast film 50 so that the polarization shaft-orientations component of the polarizing plate 24 of polarization 56 may serve as max.

[0052] In addition, a light filter 12 and the flattening film 13 may be arranged at the incidence side of the liquid crystal layer 20.

[0053] Here, the case where the liquid crystal layer 20 is a SSFLC layer is briefly explained as a modification of this example.

[0054] In drawing 1, the incident light which has random polarization turns into the linearly polarized light parallel to the polarization shaft of a polarizing plate 10 by passing a polarizing plate 10. If it explains taking the case of the case of a white display, the above-mentioned linearly polarized light will turn into polarization which has a component parallel to the polarization shaft of the polarizing plate 24 by the side of outgoing radiation by the birefringence anisotropy which the liquid crystal layer 20 has. Furthermore, the phase contrast δ according to the incident angle of incident light is given with a light filter 12 and the flattening film 13. And the phase contrast δ according to the incident angle of this incident light is compensated with the phase contrast film 50.

[0055] Next, the second example is explained. This example differs in the location of a phase contrast

film from the first example. The typical sectional view showing the second example of a liquid crystal display component is shown in drawing 3 .

[0056] In drawing 3 , 60 is a phase contrast film and is inserted between the polarizing plates 10 and glass substrates 11 by the side of incidence. Since other members and those physical relationship are the same as that of drawing 1 (first example of an embodiment), the same sign as drawing 1 is attached and explanation is omitted.

[0057] Next, the polarization condition of this component is explained.

[0058] As for drawing 4 , only the member to which a polarization condition is changed among these components extracts and shows (a polarizing plate 10, the phase contrast film 60, a light filter 12, the flattening film 13, the liquid crystal layer 20, and the polarizing plate 24). The light which carries out incidence of 62 to this component, and the light to which polarization of the outgoing radiation light from the liquid crystal layer 20 and 66 pass polarization of the outgoing radiation light from a light filter 12 and the flattening film 13, 67 passes a polarizing plate 24, and polarization of the outgoing radiation light from a polarizing plate 10 and 64 carry out outgoing radiation of 63 for polarization of the outgoing radiation light from the phase contrast film 60 and 65 from this component are shown. However, incident light 62 presupposes that incidence is carried out from across with a certain include angle to the screen. In addition, the liquid crystal layer 20 is TN liquid crystal layer, and drawing 4 is the case where it is indicating by white.

[0059] In drawing 4 , the incident light 62 which has random polarization turns into the linearly polarized light 63 with a polarizing plate 10. Since the phase contrast film 60 which has retardation δ has a forward 1 shaft optical anisotropy with an optical axis vertical to the screen (substrate side), it gives phase contrast- δ according to the incident angle to incident light. Therefore, the linearly polarized light 63 turns into elliptically polarized light 64 by passing the phase contrast film 60. 90 degrees of plane of polarization rotate in the liquid crystal layer 20, and elliptically polarized light 64 turns into elliptically polarized light 65. And since a light filter 12 and the flattening film 13 have a negative 1 shaft optical anisotropy with an optical axis vertical to the screen (substrate side), they give the phase contrast δ of reverse to incident light in the phase contrast film 60. Therefore, elliptically polarized light 65 turns into the linearly polarized light 66 by passing a light filter 12 and the flattening film 13. Since the linearly polarized light 66 is almost parallel to the polarization shaft of a polarizing plate 24 in the case of drawing 4 , the reinforcement of the outgoing radiation light 67 is large, and a white display is obtained.

[0060] Thus, since the phase contrast film 60 compensates the phase contrast δ produced by the light filter 12 and the flattening film 13 by giving phase contrast- δ beforehand to polarization, it can raise the angle-of-visibility property of a liquid crystal device.

[0061] In addition, a light filter 12 and the flattening film 13 are seen from the liquid crystal layer 20, and may be arranged at the incidence side of light.

[0062] As the third example, the same liquid crystal display component as the second example is explained except arranging a light filter 12 and the flattening film 13 to the incidence side of the liquid crystal layer 20.

[0063] The typical sectional view showing the third example of a liquid crystal display component is shown in drawing 5 . Moreover, only the member to which a polarization condition is changed among these components is extracted, and it is shown in drawing 6 . In addition, the liquid crystal layer 20 is TN liquid crystal layer, and drawing 6 is the case where it is indicating by white.

[0064] In drawing 6 , the incident light 32 which has random polarization turns into the linearly polarized light 33 with a polarizing plate 10. Since the phase contrast film 30 which has retardation δ has a forward 1 shaft optical anisotropy with an optical axis vertical to the screen (substrate side), it gives phase contrast- δ according to the inclination to incident light. Therefore, the linearly polarized light 33 turns into elliptically polarized light 34 by passing the phase contrast film 30. Since a light filter 12 and the flattening film 13 have a negative 1 shaft optical anisotropy with an optical axis vertical to the screen (substrate side), they give the phase contrast δ of reverse to incident light in the phase contrast film 30. Therefore, elliptically polarized light 34 turns into the linearly polarized light 35

by passing a light filter 12 and the flattening film 13. And 90 degrees of plane of polarization rotate in the liquid crystal layer 20, and the linearly polarized light 35 turns into the linearly polarized light 36. Since the linearly polarized light 36 is almost parallel to the polarization shaft of a polarizing plate 24 in the case of drawing 6, the reinforcement of the outgoing radiation light 37 is large, and a white display is obtained.

[0065] Thus, since the phase contrast film 30 compensates the phase contrast delta produced by the light filter 12 and the flattening film 13 by giving phase contrast-delta beforehand to polarization, it can raise the angle-of-visibility property of a liquid crystal device.

[0066] Moreover, a phase contrast film may be inserted between a glass substrate 23 and the polarizing plate 24 by the side of outgoing radiation, as shown in drawing 7.

[0067] As for a phase contrast film, a light filter 12, and the flattening film 13, in the above example, it is more desirable that it sees from the liquid crystal layer 20, and is in the same side. By seeing these from the liquid crystal layer 20, and arranging to the same side, it is because the polarization which passes the liquid crystal layer 20 turns into the linearly polarized light. If the polarization which passes a liquid crystal layer turns into elliptically polarized light, in the case of TN liquid crystal device, 90 degrees of plane of polarization may not rotate thoroughly, but the display engine performance may be inferior.

[0068] Moreover, generally the thickness of a light filter 12 and the flattening film 13 is 1-2 micrometers and about 2-4 micrometers, respectively, and since the maximum of δ_{tan} is 0.03 to about 0.06, the maximum of retardation δ_{tand} of a phase contrast film is suitably chosen in 30-360nm.

[0069] In the above example, although explained mainly taking the case of TN liquid crystal device, even if STN, SSFLC(s), etc. are the other modes, the operation of this invention to the optical anisotropy produced by members other than liquid crystal is the same.

[0070] The example of an experiment of this invention is continuously explained using a drawing. The following examples of an experiment are related with the surface passivation ferroelectric liquid crystal (SSFLC) component which used chiral smectic liquid crystal.

[0071] (Example 1 of an experiment) After forming Cr film in the glass substrate of 300mmx320mm and 1.1mm thickness by the spatter, by the photolithography, patterning was carried out and the protection-from-light layer of 100nm of thickness was formed in it. Next, after applying with a spinner the polyimide system photopolymer with which the pigment was distributed, patterning was carried out by the photolithography and the light filter film of 1.5 micrometers of thickness was formed (R, G, and B). Furthermore, the polyamide system flattening film of 1.5 micrometers of thickness was formed by coating. Then, after forming ITO by the spatter, by the photolithography, patterning was carried out and the transparent electrode of the shape of a stripe of 150nm of thickness was formed. Then, the polyimide system orientation film of 20nm of thickness was formed by flexographic printing and baking, and rubbing processing was performed.

[0072] By making the substrate which prepared an ITO transparent electrode and the polyimide system orientation film, and carried out rubbing processing counter, and sticking with epoxy system adhesives on a substrate, similarly, the liquid crystal cell was produced, and level orientation of the chiral smectic liquid crystal constituent of a pyrimidine system was poured in and carried out.

[0073] It continued and the birefringence film which has the forward optical anisotropy which carried out vertical orientation was obtained by applying a side-chain mold liquid crystallinity macromolecule to a high polymer film. And this birefringence film was stuck on the outside of the substrate which has a light filter, and the polarizing plate was stuck on the outside of a both-sides substrate at Kios Nicole. And the back light was prepared so that light might carry out incidence from the substrate side which does not have a light filter, the electrical-potential-difference impression means was established by the well-known approach, and it considered as the liquid crystal display.

[0074] Thus, it is as the typical sectional view being shown in drawing 1 in the first example of an embodiment which mentioned the produced liquid crystal display above.

[0075] The maximum of δ_{tand} which the sum d of the thickness of a light filter and the flattening film produced by 3.0 micrometers and these was 135nm. In this example of an experiment, it designed so

that the maximum of $\Delta n d$ of a birefringence film might be set to 135nm.

[0076] The result of having measured the angle-of-visibility property in the liquid crystal display of this example of an experiment is shown in drawing 8. ϕ in drawing 8 and θ express the azimuth of the transmitted light projected on the screen, respectively, and the angle of inclination from a screen normal as they are shown in drawing 10. Moreover, the curve in drawing 8 is a ** contrast curve, and it is shown that the inside serves as high contrast. The azimuth dependency of contrast is small and the liquid crystal display of this example is dramatically excellent in the angle-of-visibility property.

[0077] (Example 2 of an experiment) The liquid crystal display was produced like the example 1 of an experiment. However, the birefringence film was not prepared.

[0078] The result of having measured the angle-of-visibility property in the liquid crystal display of this example of an experiment is shown in drawing 9. An azimuth shows that is large and an angle-of-visibility property is not so good. [of change of contrast]

[0079] (Example 3 of an experiment) The liquid crystal display was produced like the example 1 of an experiment. However, the birefringence film was prepared in the outside (between a glass substrate and polarizing plates) of the substrate which does not have a light filter. It is as the typical sectional view being shown in drawing 3 in the second example of an embodiment which mentioned above the liquid crystal display of this example of an experiment.

[0080] When the angle-of-visibility property in the liquid crystal display of this example of an experiment was measured, it turned out like the example 1 of an experiment that the azimuth dependency of contrast is small and the angle-of-visibility property is dramatically excellent.

[0081] (Example 4 of an experiment) The liquid crystal display was produced like the example 1 of an experiment. However, the birefringence film was prepared in the outside of a both-sides substrate.

[0082] When the angle-of-visibility property in the liquid crystal display of this example of an experiment was measured, it turned out like the example 1 of an experiment that the azimuth dependency of contrast is small and the angle-of-visibility property is dramatically excellent.

[0083] The examples 1, 3, and 4 of an experiment are examples of this invention among the above example of an experiment, and the example 2 of an experiment is an example of a comparison. By preparing a phase contrast film shows that the angle-of-visibility property is improved substantially so that clearly from the comparison of the example 1 (drawing 8) of an experiment, and the example 2 (drawing 9) of an experiment.

[0084] Although the above-mentioned example of an experiment was performed using chiral smectic liquid crystal, other liquid crystal may be used. Moreover, it may not be what also restricted the liquid crystal device of this invention thru/or the configuration of a liquid crystal display to the above-mentioned example of an embodiment, and the example of an experiment, for example, you may be a liquid crystal display component, a liquid crystal shutter, etc. in monochrome mode in which a light filter is not prepared.

[Translation done.]

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The typical sectional view showing the liquid crystal device in the first example of this invention.

[Drawing 2] The typical exploded view showing the polarization condition in the first example of this invention.

[Drawing 3] The typical sectional view showing the liquid crystal device in the second example of this invention.

[Drawing 4] The typical exploded view showing the polarization condition in the second example of this invention.

[Drawing 5] The typical sectional view showing the liquid crystal device in the third example of this invention.

[Drawing 6] The typical exploded view showing the polarization condition in the third example of this invention.

[Drawing 7] The typical sectional view showing the liquid crystal device in the modification of the third example of this invention.

[Drawing 8] Drawing showing the measurement result of the angle-of-visibility property in the example 1 of an experiment of this invention.

[Drawing 9] Drawing showing the measurement result of the angle-of-visibility property in the example 2 of an experiment of this invention.

[Drawing 10] The perspective view explaining the measuring method of the angle-of-visibility property in the example of an experiment of this invention.

[Drawing 11] The typical sectional view of a general liquid crystal device.

[Drawing 12] Typical perspective drawing showing a surface passivation ferroelectric liquid crystal component.

[Description of Notations]

10 Polarizing Plate

11 Glass Substrate

12 Light Filter

13 Flattening Film

14 Transparent Electrode

15 Orientation Film

20 Liquid Crystal Layer

21 Orientation Film

22 Transparent Electrode

23 Glass Substrate

24 Polarizing Plate

30 Phase Contrast Film

32 Incident Light

33, 34, 35, 36 Polarization
37 Hikaru Idei
40 Phase Contrast Film
50 Phase Contrast Film
52 Incident Light
53, 54, 55, 56 Polarization
57 Hikaru Idei
60 Phase Contrast Film
62 Incident Light
63, 64, 65, 66 Polarization
67 Hikaru Idei
100 Polarizing Plate
101 Glass Substrate
102 Light Filter
103 Flattening Film
104 Transparent Electrode
105 Orientation Film
110 Liquid Crystal Layer
111 Orientation Film
112 Transparent Electrode
113 Glass Substrate
114 Polarizing Plate
121a, 121b Substrate
122 Ferroelectric Liquid Crystal Layer
131a, 131b Electrode
133a The 1st stable state
133b The 2nd stable state
134a, 134b Dipole moment

[Translation done.]

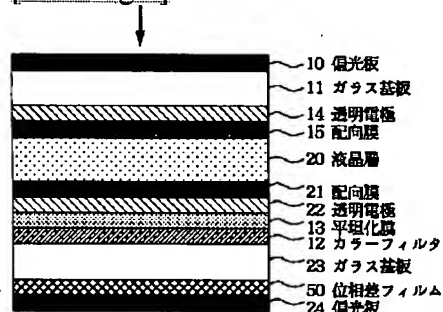
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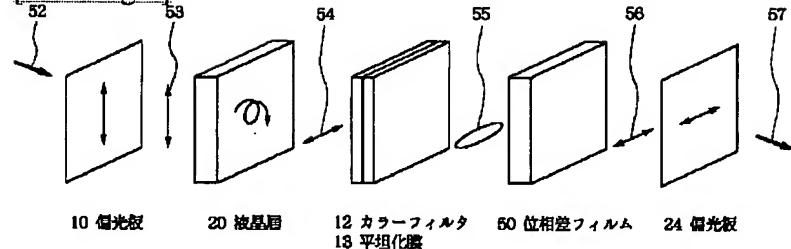
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DRAWINGS

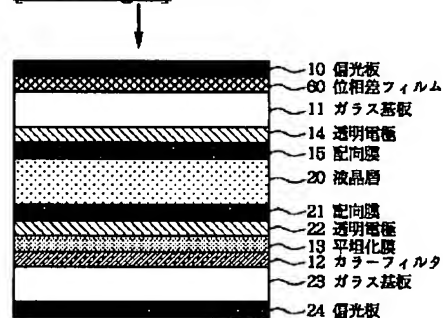
[Drawing 1]



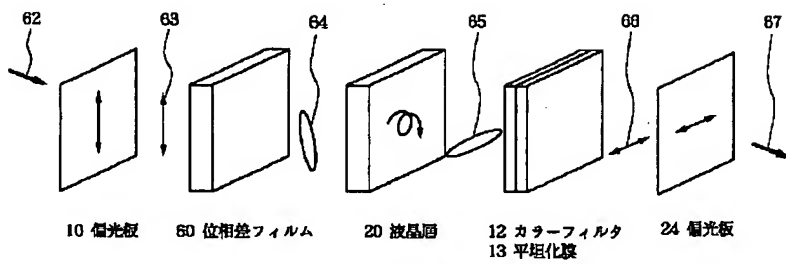
[Drawing 2]



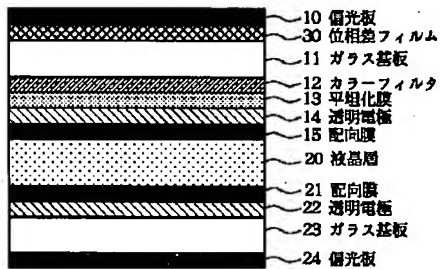
[Drawing 3]



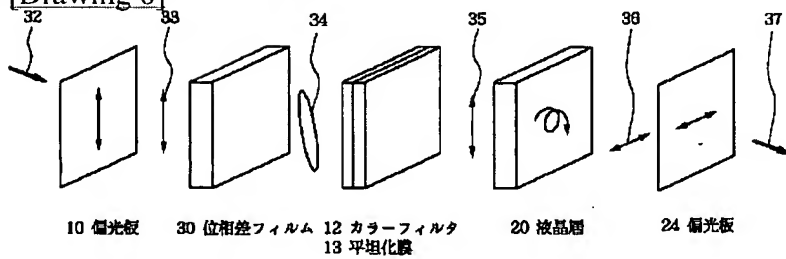
[Drawing 4]



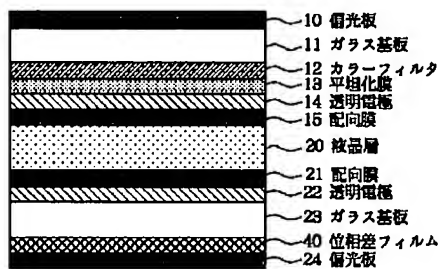
[Drawing 5]



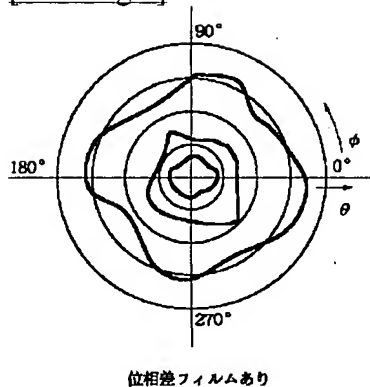
[Drawing 6]



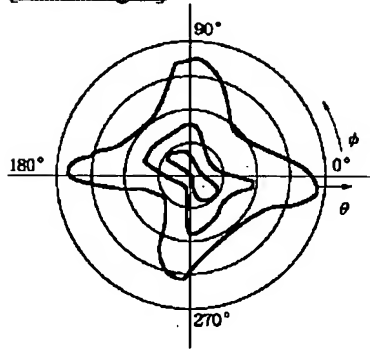
[Drawing 7]



[Drawing 8]

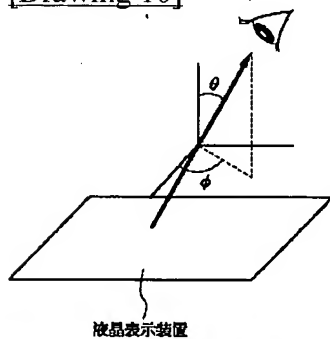


[Drawing 9]



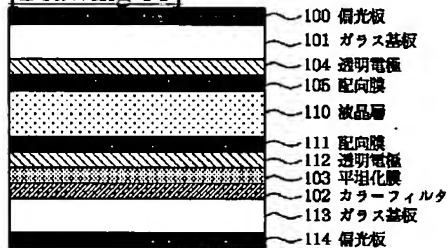
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[Drawing 10]

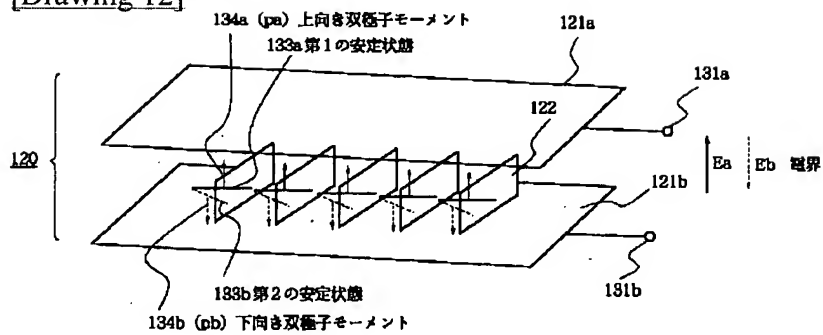


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[Drawing 11]



[Drawing 12]



[Translation done.]

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TITLE: LIQUID CRYSTAL ELEMENT AND LIQUID CRYSTAL
DEVICE

PUBN-DATE: February 7, 1997

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APPL-DATE: July 14, 1995

INT-CL (IPC): G02F001/1335, G02F001/141

ABSTRACT:

PROBLEM TO BE SOLVED: To improve optical characteristics and visual field angle characteristics by providing a 1st uniaxial optically anisotropic member which has its optical axis oriented at right angles to the substrate surface of the liquid crystal element and a 2nd uniaxial optically anisotropic member which is different in the sign of optical anisotropy from the 1st member.

SOLUTION: This element is composed of polarizing plates 10 and 24, glass

substrates 11 and 23 between which liquid crystal is sandwiched, a color filter

12 which has specific spectral characteristics, a flattening film 13 which corrects unevenness of the color filter 12, transparent electrodes 14 and 22

which apply a voltage to the liquid crystal, pixel by pixel, orientation films 15 and 21 which orient the liquid crystal in a desired orientation state, a liquid crystal layer 20, and a phase difference film (birefringent film and retardation film) 50 which has positive uniaxial anisotropy and is perpendicular to the glass substrates 11 and 23. Then the retardation of the

1st uniaxial optical anisotropic member which is oriented at right angles to

the substrate surface of the liquid crystal element is compensated by the 2nd

uniaxial anisotropic member which is different in the sign of anisotropy from

the 1st uniaxial optical anisotropic member and oriented at right angles to the

substrate surface of the liquid crystal element.

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